

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
22 November 2001 (22.11.2001)

PCT

(10) International Publication Number
WO 01/88592 A2

(51) International Patent Classification⁷: G02B 21/00 (81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(21) International Application Number: PCT/IL01/00410

(22) International Filing Date: 10 May 2001 (10.05.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data: 09/570,972 15 May 2000 (15.05.2000) US

(71) Applicant (for all designated States except US): ORBOTECH LTD. [IL/IL]; P.O.B. 215, 81102 Yavne (IL).

(72) Inventors; and

(75) Inventors/Applicants (for US only): KATZIR, Yigal [IL/IL]; 34 Ben Eliezer Street, 75229 Rishon Lezion (IL). GORLIK, Demitry [IL/IL]; 4 Nofar Street, Apt. 3, 81207 Yavne (IL).

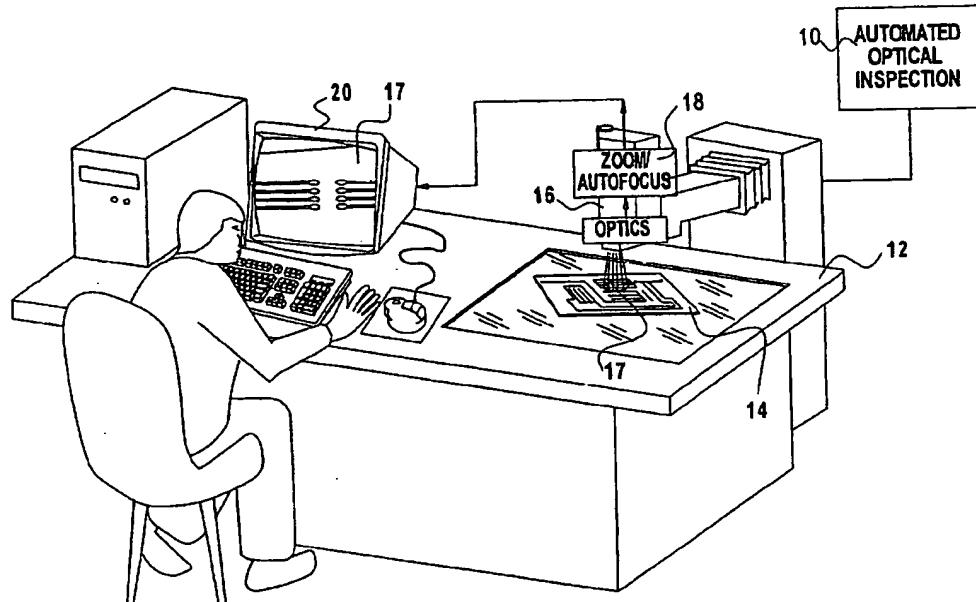
(74) Agent: FAIBISCH, Michael; c/o Orbotech Ltd., P.O. Box 215, 81102 Yavne (IL).

Published:

— without international search report and to be republished upon receipt of that report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: MICROSCOPE INSPECTION SYSTEM



WO 01/88592 A2

(57) Abstract: An electrical circuit inspection system including an eyepiece operative to collimate light received from a portion of interest in an electrical circuit, a zoom and/or automatic focus video camera assembly receiving collimated light from the eyepiece and a display operative to receive a video output from the zoom video camera and to display a magnified image of the portion of interest.

MICROSCOPE INSPECTION SYSTEM

FIELD OF THE INVENTION

The present invention relates to electrical circuit inspection systems generally and more particularly to electrical circuit inspection systems having automatic focus and zoom functionality.

5

BACKGROUND OF THE INVENTION

Electrical circuit inspection systems of various types are known in the art. Generally, they do not include automatic focus and zoom functionalities. Magnifying video camera systems having automatic focus and zoom functionality are known in the art.

10 Conventionally, systems of this type employ microscopes having such functionality upstream of the eyepiece. Such microscopes are complicated and very expensive.

As line widths in electrical circuits decrease with advancing manufacturing technology, the importance of fine focus in inspection systems increases accordingly.

15

SUMMARY OF THE INVENTION

The present invention seeks to provide an electrical circuit inspection system which provides zoom and/or automatic focus functionality and employs standard optical components and which is substantially less expensive than prior art systems.

20

There is thus provided in accordance with a preferred embodiment of the present invention an electrical circuit inspection system comprising a lens preferably operative to image substantially at infinity light received from a portion of interest in an electrical circuit; a zoom video camera assembly receiving light imaged substantially at infinity from the lens; and a display preferably operative to receive a video output from the zoom video camera assembly and to display a magnified image of the portion of interest.

25

In accordance with a preferred embodiment of the present invention the electrical circuit inspection system also includes a first stage lens preferably operative to view the portion of interest and to focus light therefrom onto a focal plane of the lens.

Additionally, in accordance with a preferred embodiment of the present invention, the first stage lens is a relay lens preferably operative to provide a non-magnified image of a portion of interest in an electrical circuit. Alternatively the first stage lens is an

objective lens preferably operative to provide a magnified image of a portion of interest in an electrical circuit..

Furthermore, in accordance with a preferred embodiment of the present invention, the electrical circuit inspection system includes a positioner preferably operative to 5 position the electrical circuit such that a portion of interest is viewed through the lens and preferably the positioner is operated by an output received from an automated optical inspection system which identifies regions of the electrical circuit thought possibly to include defects.

10 Alternatively, in accordance with a preferred embodiment of the present invention, the electrical circuit inspection system includes a positioner preferably operative to position the electrical circuit such that a portion of interest is viewed through the first stage lens and preferably the positioner is operated by an output received from an automated optical inspection system which identifies regions of the electrical circuit thought possibly to include defects.

15 Still alternatively, in accordance with a preferred embodiment of the present invention, the electrical circuit inspection includes a positioner preferably operative to position the electrical circuit such that a portion of interest is viewed through the relay lens and preferably the positioner is operated by an output received from an automated optical inspection system which identifies regions of the electrical circuit thought possibly to include 20 defects.

25 There is thus provided in accordance with a preferred embodiment of the present invention an electrical circuit inspection system including a lens preferably operative to substantially image at infinity light received from a portion of interest in an electrical circuit; an auto-focus video camera assembly receiving light imaged substantially at infinity from the lens; and a display preferably operative to receive a video output from the auto-focus video camera and to display an automatically focused image of the portion of interest in an electrical circuit.

30 In accordance with a preferred embodiment of the present invention the electrical circuit inspection system also includes a first stage lens preferably operative to view the portion of interest in the electrical circuit and to focus light therefrom onto a focal plane of the lens.

5 Additionally, in accordance with a preferred embodiment of the present invention, the first stage lens is a relay lens preferably operative to provide a non-magnified image of a portion of interest in an electrical circuit. Alternatively, the first stage lens is an objective lens preferably operative to provide a magnified image of a portion of interest in an electrical circuit.

10 Furthermore, in accordance with a preferred embodiment of the present invention, the electrical circuit inspection system includes a positioner preferably operative to position the electrical circuit such that a portion of interest is viewed through the lens and preferably the positioner is operated by an output received from an automated optical inspection system which identifies regions of the electrical circuit thought possibly to include defects.

15 Alternatively, in accordance with a preferred embodiment of the present invention, the electrical circuit inspection system includes a positioner preferably operative to position the electrical circuit such that a portion of interest is viewed through the first stage lens and preferably the positioner is operated by an output received from an automated optical inspection system which identifies regions of the electrical circuit thought possibly to include defects.

20 Still alternatively, in accordance with a preferred embodiment of the present invention, the electrical circuit inspection system includes a positioner preferably operative to position the electrical circuit such that a portion of interest is viewed through the relay lens and preferably the positioner is operated by an output received from an automated optical inspection system which identifies regions of the electrical circuit thought possibly to include defects.

25 There is thus provided in accordance with a preferred embodiment of the present invention an electrical circuit inspection system including a lens preferably operative to substantially image at infinity light received from a portion of interest in an electrical circuit; a zoom and automatic focus video camera assembly receiving light imaged substantially at infinity from the lens; and a display preferably operative to receive a video output from the zoom and automatic focus video camera and to display a magnified and automatically focused image of the portion of interest.

30 In accordance with a preferred embodiment of the present invention the

electrical circuit inspection system also includes a first stage lens preferably operative to view the portion of interest and to focus light therefrom onto a focal plane of the lens.

Additionally in accordance with a preferred embodiment of the present invention, the first stage lens is a relay lens preferably operative to provide a non-magnified image of a portion of interest in an electrical circuit. Alternatively, the first stage lens is an objective lens preferably operative to provide a magnified image of a portion of interest in an electrical circuit.

Furthermore, in accordance with a preferred embodiment of the present invention, the electrical circuit inspection includes a positioner preferably operative to position the electrical circuit such that a portion of interest is viewed through the lens and preferably the positioner is operated by an output received from an automated optical inspection system which identifies regions of the electrical circuit thought possibly to include defects.

Alternatively in accordance with a preferred embodiment of the present invention, the electrical circuit inspection system includes a positioner preferably operative to position the electrical circuit such that a portion of interest is viewed through the first stage lens and preferably the positioner is operated by an output received from an automated optical inspection system which identifies regions of the electrical circuit thought possibly to include defects.

Still alternatively in accordance with a preferred embodiment of the present invention, the electrical circuit inspection system includes a positioner preferably operative to position the electrical circuit such that a portion of interest is viewed through the relay lens and preferably the positioner is operated by an output received from an automated optical inspection system which identifies regions of the electrical circuit thought possibly to include defects.

There is thus provided in accordance with a preferred embodiment of the present invention an inspection system including a lens preferably operative to image substantially at infinity light received from a region of interest, a zoom and/or automatic focus video camera assembly receiving light from the lens imaged substantially at infinity and a display preferably operative to receive a video output from the zoom and/or automatic focus video camera and to display a magnified image of the region of interest.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description, taken in conjunction with the drawings in which:

Fig. 1 is a simplified pictorial illustration of an electrical circuit inspection system constructed and operative in accordance with a preferred embodiment of the present invention;

Figs. 2A & 2B are simplified illustrations of two embodiments of the system of Fig. 1; and

Figs. 3A & 3B are simplified optical illustrations of the embodiments of Figs. 10 2A & 2B respectively.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Reference is now made to Fig. 1, which is a simplified pictorial illustration of an electrical circuit inspection system constructed and operative in accordance with a preferred embodiment of the present invention. As seen in Fig. 1, an output from an automatic optical inspection station 10 is received by a positioner 12 which suitably positions an electrical circuit, such as a printed circuit board 14, under a microscope 16.

The automatic optical inspection station 10 may be any suitable automatic optical inspection station and is preferably a Model PC Micro II commercially available from Orbotech, Ltd. of Yavne, Israel. The positioner 12 may be any suitable positioner and is 10 preferably a positioner such as that incorporated in a Model VRS 4M, commercially available from Orbotech, Ltd. of Yavne, Israel.

A lens forming part of microscope 16, receives light from a portion 17 of the printed circuit board 14, to which an operator's attention is directed by the output from the automatic optical inspection station 10 which suitably positions that portion in the field of 15 view of the microscope 16. In accordance with a preferred embodiment of the present invention, a zoom and/or automatic focus video camera assembly 18 forming part of the microscope 16 is disposed downstream of the lens to receive light from the lens that is substantially imaged at infinity so as to be substantially collimated. A display 20 receives a video output from the camera assembly 18 and displays a magnified image of the portion 17 of 20 the printed circuit board 14 in which a defect is believed to possibly exist so that the operator may decide whether the defect is a real defect or a false alarm.

In accordance with a preferred embodiment of the present invention the camera assembly 18 is preferably a Sony Model FCB-1X47P which provides both zoom and automatic focus functionality. The display 20 may be any suitable high resolution display, 25 such as a Model PVM-14M4E 14" Sony color video monitor.

Reference is now made to Figs. 2A & 2B, which are simplified illustrations of two embodiments of the system of Fig. 1. As seen in Fig. 2A, the portion of interest 17 on a printed circuit board 14 is viewed via a lens, which is preferably a first stage lens such as a relay objective lens 22, and subsequently via an eyepiece 24. Light from the eyepiece 24 is 30 received by camera assembly 18, typically including its own viewing optics 19, which

provides an output to display 20.

A preferred relay objective lens 22 is a Carl Zeiss S-Planar 74mm f/4 lens and a preferred eyepiece is a Leitz Wetzlar Periplan GW 6.3x 39.7 mm lens.

Fig. 2B illustrates an alternative embodiment of the invention, wherein the 5 relay objective lens 22 is obviated and an infinity corrected objective lens 34 is employed. The printed circuit board 14 is placed substantially in the focal plane of infinity corrected objective lens 34 to form an image substantially at infinity. The image formed by infinity corrected objective lens 34 can be viewed directly by camera assembly 18 provided that viewing optics 19 are employed. In the embodiment of Fig. 2B, due to the absence of relay 10 objective lens 22, microscope 16 must be placed much closer to the printed circuit board 14 as compared to the embodiment of Fig. 2A.

Reference is now made to Figs. 3A & 3B, which are simplified optical illustrations of the embodiments of Figs. 2A & 2B respectively. Turning to Fig. 3A, it is seen that relay objective lens 22, whose focal point is indicated as F1, is preferably separated from the printed circuit board 14 by a distance of about 148 mm. The eyepiece 24 is preferably separated from the relay objective lens 22 by 187.7 mm and its focal point is indicated as F2. It is noted that relay objective lens 22 preferably is located a distance of $2 \times F1$ from the surface 15 being viewed of printed circuit board 14, and that the focal point F2 of eyepiece 24 adjacent the relay objective lens 22 is located at a distance of $2 \times F1$ from the relay objective lens 22. It 20 is appreciated that relay objective lens 22 may be substituted by any suitable objective lens operative to form an intermediate image in the vicinity of focal plane f2 of eyepiece 24, and that such intermediate image may be with or without magnification.

Fig. 3A also illustrates viewing optics 19 and a CCD focal plane 28 of camera assembly 18 (Fig. 2A). The focal length of viewing optics 19 is indicated as F3. Preferably, 25 the focal length ratio between viewing optics 19 and eyepiece 24 is such that a 2 - 3 times magnification is produced at the focal plane 28.

Turning to Fig. 3B, it is seen that infinity corrected objective lens 34, whose focal point is indicated as F4, is preferably separated from the printed circuit board 14 by the focal length f4.

30 Fig. 3B also illustrates viewing optics 36 and a CCD focal plane 38 of camera

assembly 18. Preferably, the focal length ration between viewing optics 36 and objective lens 34 is such that 2 - 3 times magnification is produced at the focal plane 38.

It is appreciated that although the present invention has been described particularly within the context of an electrical circuit inspection device, it may be applicable 5 equally to any other suitable type of video microscopy application, system and method.

It will be appreciated by persons skilled in the art that the present invention is not limited by what has been particularly shown and described hereinabove. Rather the scope of the present invention includes both combinations and subcombinations of the various features described hereinabove as well as variations and modifications which would occur to 10 persons skilled in the art upon reading the specification and which are not in the prior art.

C L A I M S

1. An electrical circuit inspection system comprising:

a lens operative to image substantially at infinity light received from a portion of interest in an electrical circuit;

5 a zoom video camera assembly receiving light imaged substantially at infinity from said lens; and

a display operative to receive a video output from said zoom video camera assembly and to display a magnified image of the portion of interest.

2. An electrical circuit inspection system according to claim 1 and also
10 comprising a first stage lens operative to view said portion of interest and to focus light therefrom onto a focal plane of said lens.

3. An electrical circuit inspection system according to claim 2 and wherein said first stage lens is a relay lens operative to provide a non-magnified image of said portion of interest in an electrical circuit.

15 4. An electrical circuit inspection system according to claim 2 and wherein said first stage lens is an objective lens operative to provide a magnified image of said portion of interest in an electrical circuit..

5. An electrical circuit inspection system according to claim 1 and also
20 comprising a positioner operative to position said electrical circuit such that said portion of interest is viewed through said lens.

6. An electrical circuit inspection system according to claim 5 and wherein said positioner is operated by an output received from an automated optical inspection system which identifies regions of said electrical circuit thought possibly to include defects.

25 7. An electrical circuit inspection system according to claim 2 and also comprising a positioner operative to position said electrical circuit such that said portion of interest is viewed through said first stage lens.

8. An electrical circuit inspection system according to claim 7 and wherein said

positioner is operated by an output received from an automated optical inspection system which identifies regions of said electrical circuit thought possibly to include defects.

9. An electrical circuit inspection system according to claim 3 and also comprising a positioner operative to position said electrical circuit such that said portion of interest is viewed through said relay lens.

10. An electrical circuit inspection system according to claim 9 and wherein said positioner is operated by an output received from an automated optical inspection system which identifies regions of said electrical circuit thought possibly to include defects.

11. An electrical circuit inspection system comprising:

10 a lens operative to substantially image at infinity light received from a portion of interest in an electrical circuit;

an auto-focus video camera assembly receiving light imaged substantially at infinity from said lens; and

15 a display operative to receive a video output from said auto-focus video camera and to display an automatically focused image of the portion of interest in an electrical circuit.

12. An electrical circuit inspection system according to claim 11 and also comprising a first stage lens operative to view said portion of interest in an electrical circuit and to focus light therefrom onto a focal plane of said lens.

13. An electrical circuit inspection system according to claim 12 and wherein said 20 first stage lens is a relay lens operative to provide a non-magnified image of said portion of interest in an electrical circuit.

14. An electrical circuit inspection system according to claim 12 and wherein said first stage lens is an objective lens operative to provide a magnified image of said portion of interest in an electrical circuit..

25 15. An electrical circuit inspection system according to claim 11 and also comprising a positioner operative to position said electrical circuit such that said portion of interest is viewed through said lens.

16. An electrical circuit inspection system according to claim 15 and wherein said positioner is operated by an output received from an automated optical inspection system which identifies regions of said electrical circuit thought possibly to include defects.

17. An electrical circuit inspection system according to claim 12 and also 5 comprising a positioner operative to position said electrical circuit such that said portion of interest is viewed through said first stage lens.

18. An electrical circuit inspection system according to claim 17 and wherein said positioner is operated by an output received from an automated optical inspection system which identifies regions of said electrical circuit thought possibly to include defects.

10 19. An electrical circuit inspection system according to claim 13 and also comprising a positioner operative to position said electrical circuit such that said portion of interest is viewed through said relay lens.

20. An electrical circuit inspection system according to claim 19 and wherein said positioner is operated by an output received from an automated optical inspection system 15 which identifies regions of said electrical circuit thought possibly to include defects.

21. An electrical circuit inspection system comprising:

a lens operative to substantially image at infinity light received from a portion of interest in an electrical circuit;

20 a zoom and automatic focus video camera assembly receiving light imaged substantially at infinity from said lens; and

a display operative to receive a video output from said zoom and automatic focus video camera and to display a magnified and automatically focused image of the portion of interest.

22. An electrical circuit inspection system according to claim 21 and also 25 comprising a first stage lens operative to view said portion of interest and to focus light therefrom onto a focal plane of said lens.

23. An electrical circuit inspection system according to claim 22 and wherein said first stage lens is a relay lens operative to provide a non-magnified image of said portion of

interest in an electrical circuit.

24. An electrical circuit inspection system according to claim 22 and wherein said first stage lens is an objective lens operative to provide a magnified image of said portion of interest in an electrical circuit.

5 25. An electrical circuit inspection system according to claim 21 and also comprising a positioner operative to position said electrical circuit such that said portion of interest is viewed through said lens.

10 26. An electrical circuit inspection system according to claim 25 and wherein said positioner is operated by an output received from an automated optical inspection system which identifies regions of said electrical circuit thought possibly to include defects.

27. An electrical circuit inspection system according to claim 22 and also comprising a positioner operative to position said electrical circuit such that said portion of interest is viewed through said first stage lens.

15 28. An electrical circuit inspection system according to claim 27 and wherein said positioner is operated by an output received from an automated optical inspection system which identifies regions of said electrical circuit thought possibly to include defects.

29. An electrical circuit inspection system according to claim 23 and also comprising a positioner operative to position said electrical circuit such that said portion of interest is viewed through said relay lens.

20 30. An electrical circuit inspection system according to claim 29 and wherein said positioner is operated by an output received from an automated optical inspection system which identifies regions of said electrical circuit thought possibly to include defects.

25 31. An inspection system including a lens operative to image substantially at infinity light received from a region of interest, a zoom and/or automatic focus video camera assembly receiving light from the lens imaged substantially at infinity and a display operative to receive a video output from the zoom and/or automatic focus video camera and to display a magnified image of the region of interest.

1/4

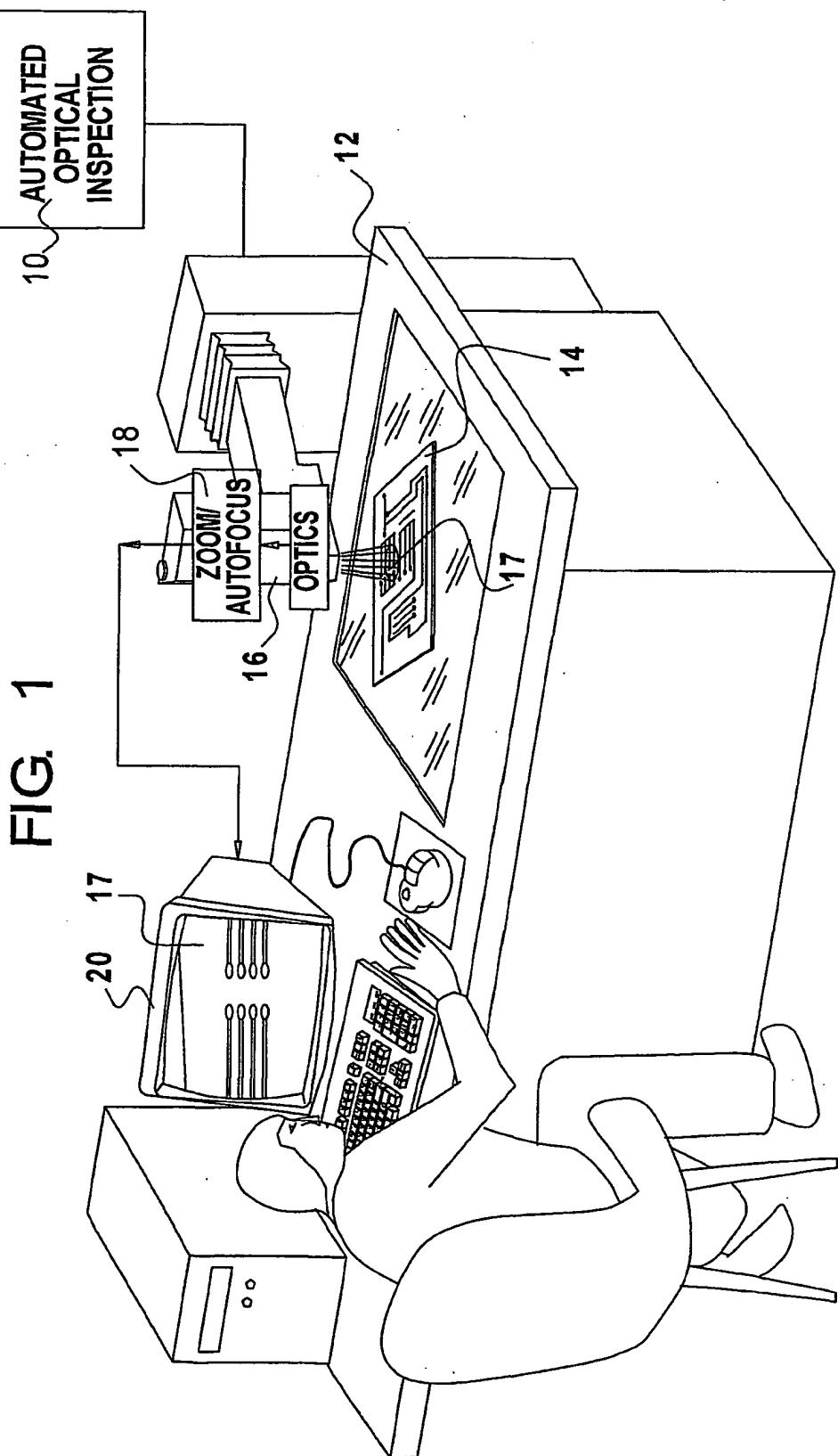
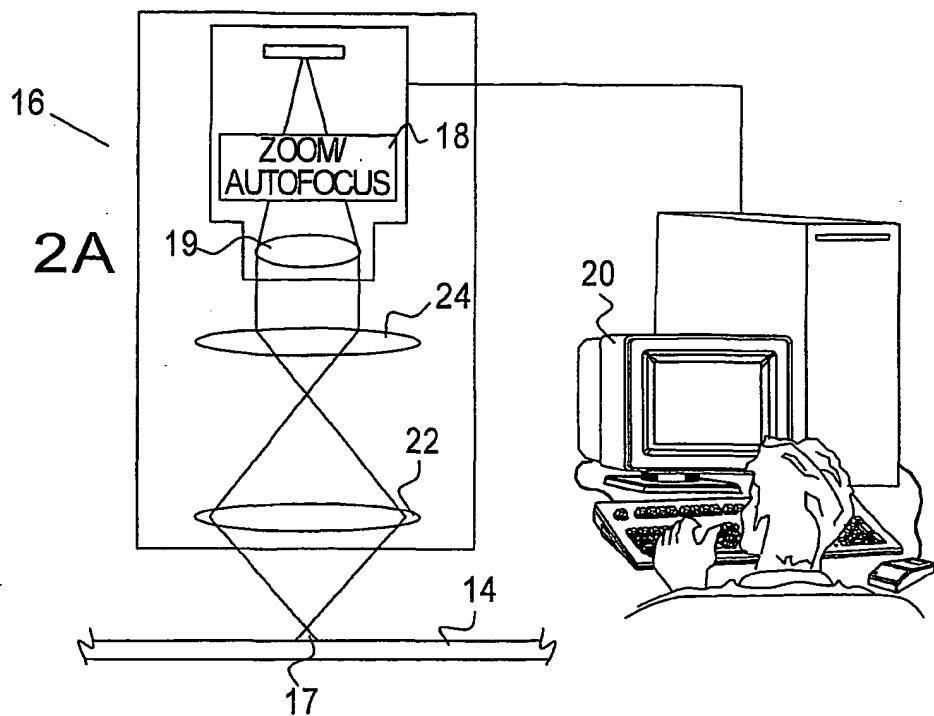
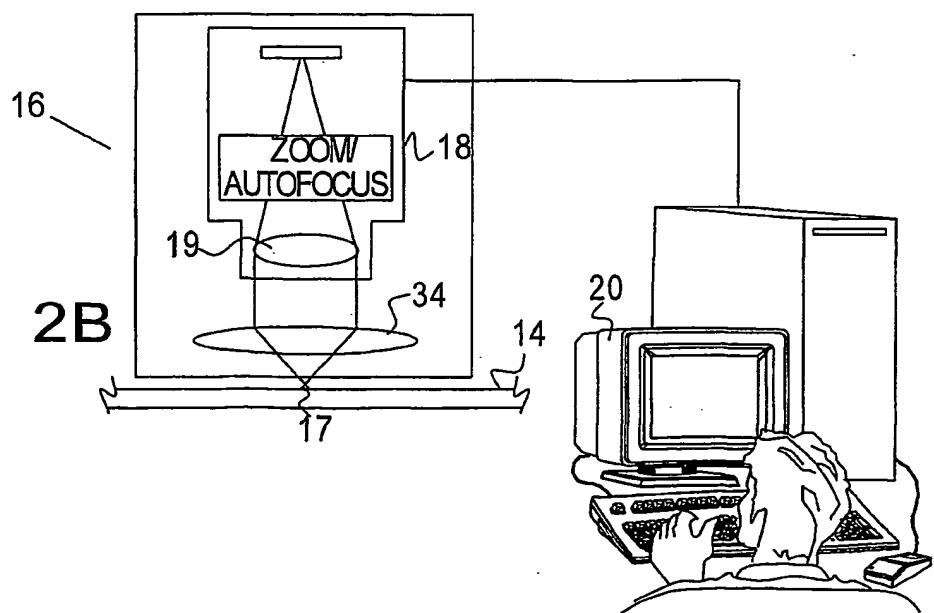


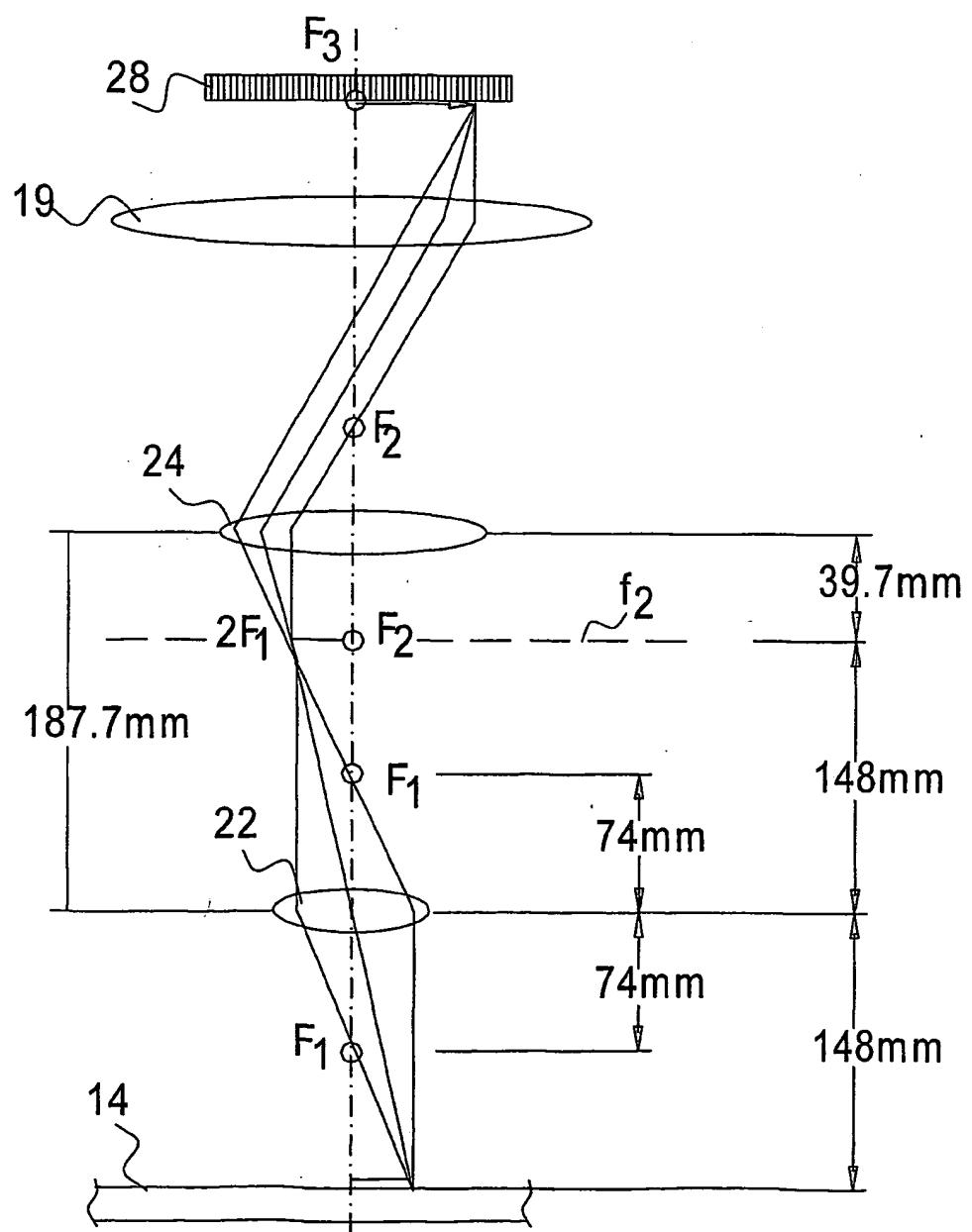
FIG. 1

2/ 4

FIG. 2A**FIG. 2B**

3/ 4

FIG. 3A



4/ 4

FIG 3B

